Lewiston Interchange Dye Trace Report
Winona County, Minnesota

Traces:
July 22nd 2008

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Introduction

In the karst region of southeast Minnesota, water tracing of surface and groundwater using fluorescent dyes has proven to be an effective method to understand water flow, travel times and the interconnections of water at the surface (streams, creeks, etc.) with groundwater. This technique has been used to map groundwater and surface water springsheds, as well as to identify contribution areas to streams. Collectively, this information is especially valuable for identifying where to focus efforts in protecting the water quality of trout streams. Trout fishing is an important economic resource in the state of Minnesota. Dye traces were conducted in

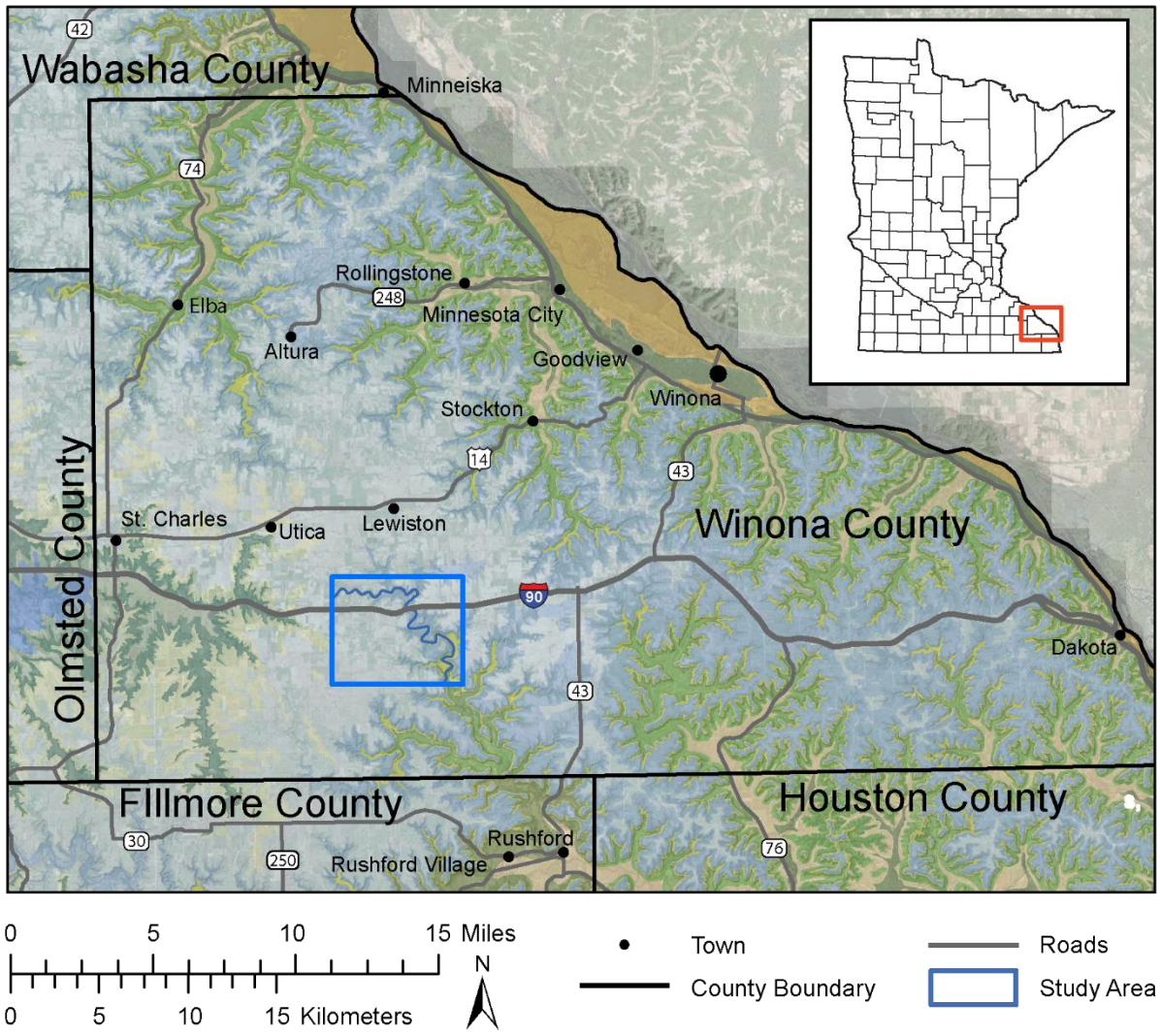

Figure 1. *Location of the Lewiston Interchange dye trace study*

Winona County south of Lewiston as part of the Environmental and Natural Resources Trust Fund (ENRTF) Springshed Mapping project. The traces described in this report were conducted to begin the process of the delineation of the springsheds in the area. This report covers traces completed in July 2008.

The Lewiston area is underlain by Ordovician Prairie du Chien Group limestone and is characterized by an array of surface karst features. The predominant surficial expression of karst features are sinkholes and springs. The underlying groundwater flow system, highlighted as the Prairie du Chien Karst System in Figure 2, is partially controlled by large integrated fracture networks that accommodate rapid groundwater flow (Runkel et. al, 2014). The traces described in this report were conducted to determine groundwater flow directions, velocities, and to aid in the delineation of groundwater springsheds that feed the springs that are the primary headwater sources for creeks south of Lewiston. In karst areas like Lewiston, it is common for the groundwater springsheds to have different boundaries than surface water watersheds.

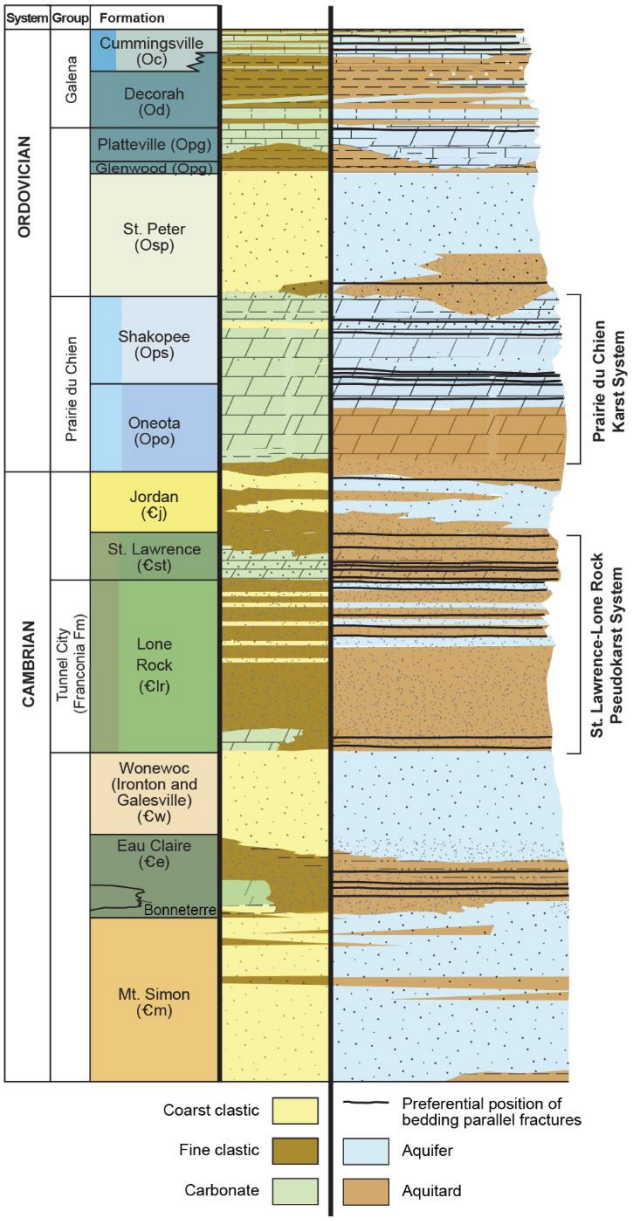

Figure 2. *Geologic and hydrogeologic attributes of Paleozoic rocks in southeastern Minnesota. Modified from Runkel et al. 2014. The dye trace for the current study was conducted in the Prairie du Chien Karst System.*

Methods

Dye tracing entails using fluorescent dyes to track groundwater flow directions and travel times. The dye is poured into a sinkhole or sinking stream. From there it flows through the karst conduit system until it re-emerges at a spring or springs. For this project, the dyes Rhodamine WT (Acid Red 388, Chem. Abs. # 37299-86-8) and Uranine C (Color Index # 45350, Chem. Abs. # 518-47-8) were used. Both direct water samples and passive dye detectors, listed as carbon (bug) analysis results in the associated summary tables, were used for monitoring springs and creeks. All the samples were analyzed at the University of Minnesota Earth Sciences Department using a scanning spectrofluorophotometer. The dye trace methods and springshed delineation protocols used in the Lewiston area dye traces are detailed in Green et al. (2014). These traces were designed and executed by Jeff Green and Andrew Peters of Minnesota DNR, Division of Ecological and Water Resources. Sample analyses, data management, and interpretation were performed by E. Calvin Alexander, Jr., Andrew Luhmann, Scott Alexander, and Betty Wheeler of the University of Minnesota Earth Sciences Department.

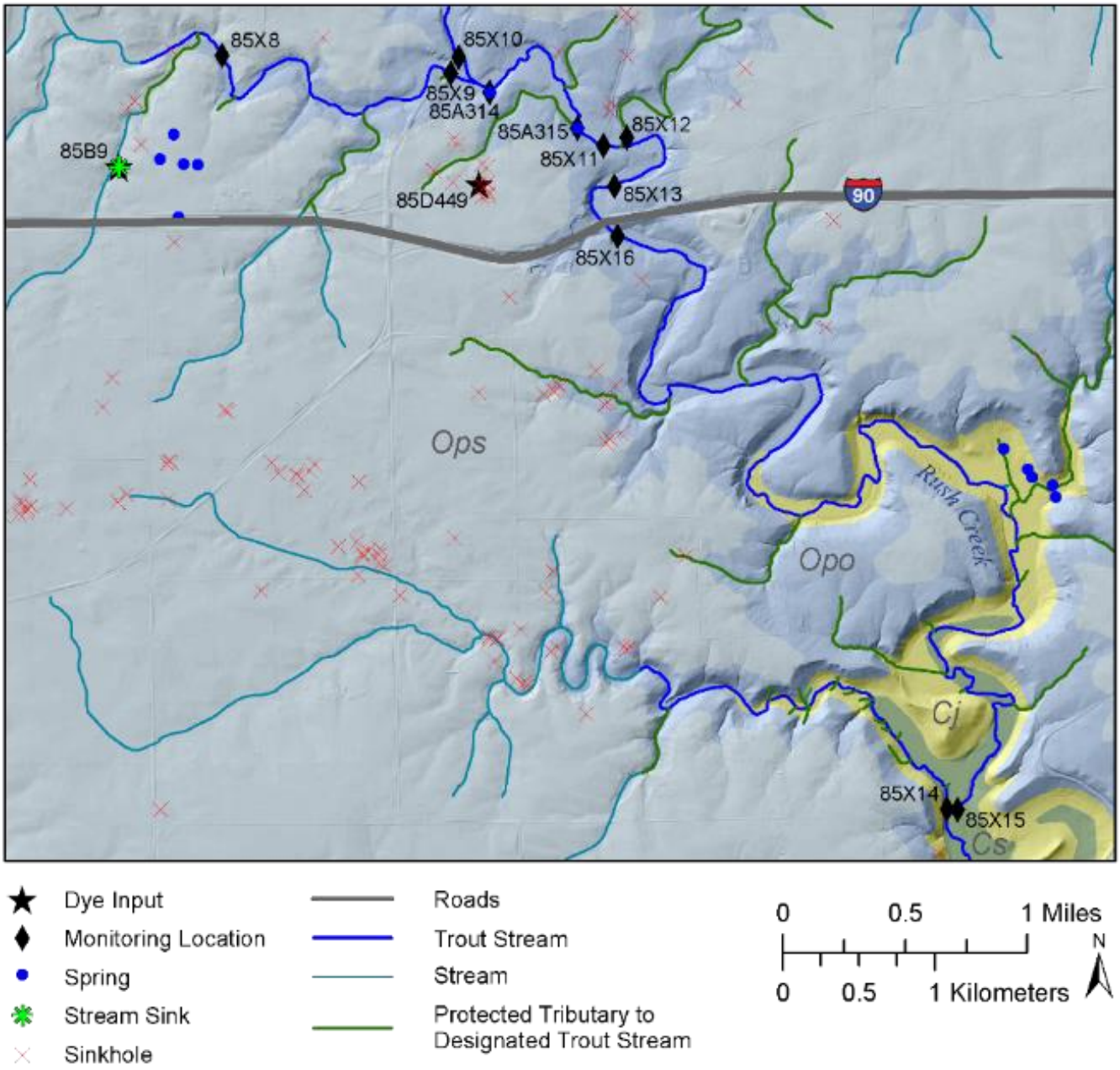

Figure 3. *Location of dye inputs, karst features and the monitoring locations for the Lewiston Interchange dye traces. The feature labeling is based on the Karst Features Database (KFD) ID number (Tipping et al., 2015) for that feature. For instance"85A314" is a shorthand version of the full ID number 85A0000314.*

Both of these traces were dry sinkhole traces, meaning that an external water source was needed to flush the dye into the sinkhole and the underlying karst groundwater flow system. The Lewiston Fire Department delivered water by fire truck to accomplish this. The locations of the dye input points and the monitoring points are listed in the attached data tables. The locations of the monitoring points are shown in Figure 3. The monitoring points are often located varying distances down the surface stream from the actual springs for logistical and redundancy reasons. The locations of the dye input points is also shown in Figure 3.

Results & Discussion

The results of these two traces are listed in the "results" data tables and displayed in Figure 4. The strong, visible dye signal and the flow time to 85A314 indicate a well-developed conduit network between the sinkhole and spring. The second trace, from stream sink 85B9, is consistent with other traces completed in the Prairie du Chien group bedrock (Green and Alexander, 2011). Though there were multiple positive dye detects at 85X9 on a tributary to Rush Creek, we did not find a discrete spring when we walked the

stream. Therefore, the inferred groundwater flow path is drawn to the head of the stream reach sampled by 85X9. The watershed that sends flow to stream sink 85B9 is approximately 616 acres and includes over a half-mile of U.S. Interstate Highway 90. Understanding the direction of groundwater flow and the relative time of travel from this stream sink would be very useful in the event of a pollution spill on the interstate highway.

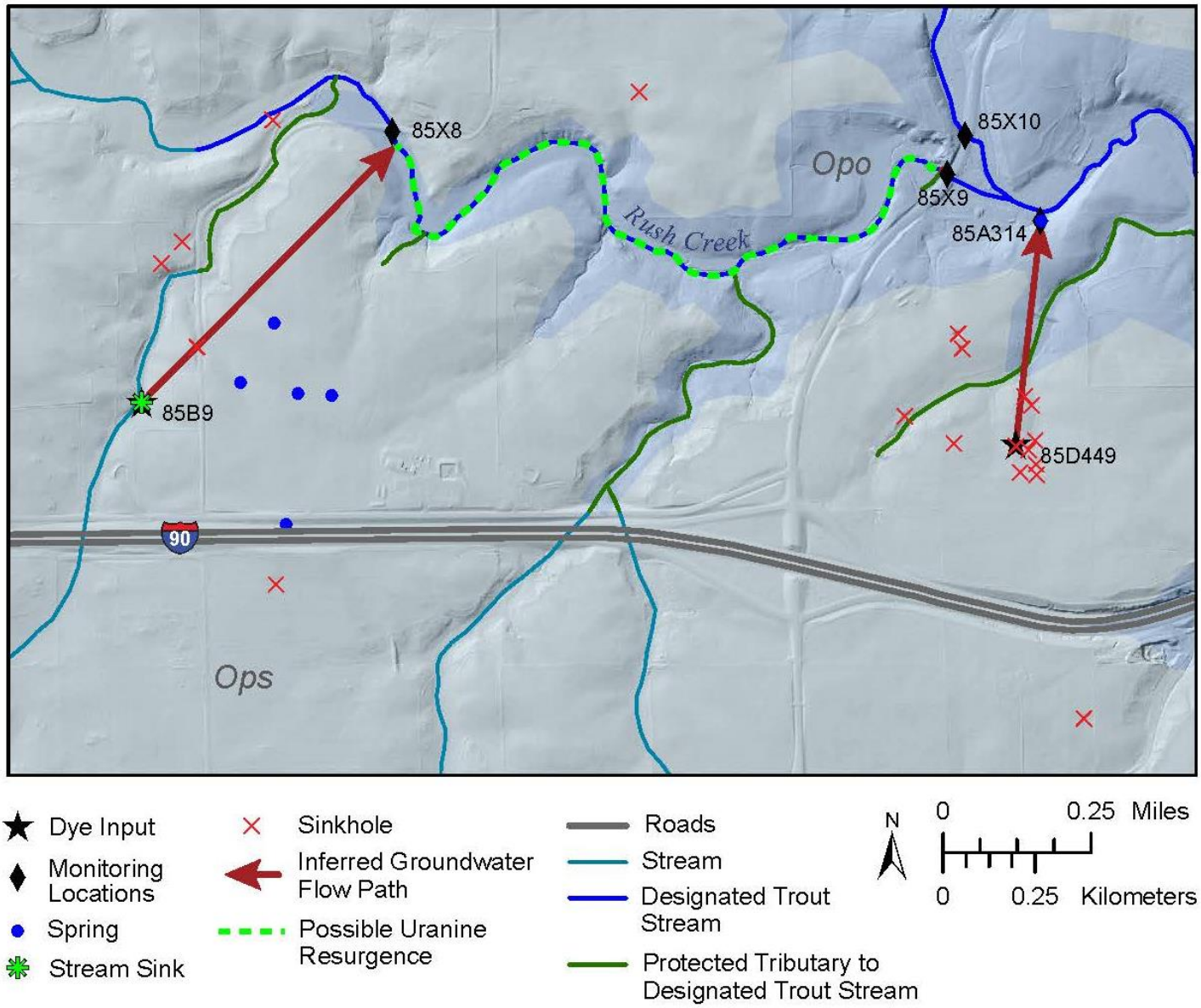

Figure 4. *Inferred groundwater flow paths. Grey shading represents the Shakopee Formation while the Blue shading represents the Oneota Dolomite Formation*

Acknowledgments

Funding for this project was provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR). We thank the several landowners who gave us permission to study the sinkholes and karst features on their property and the Lewiston Fire Department for providing truckloads of water for the dye traces.

References

Green, Jeffrey A., John D. Barry and E. Calvin Alexander, Jr. (2014) Springshed Assessment Methods for Paleozoic Bedrock Springs of Southeastern Minnesota. Report to the Legislative-Citizen Commission on Minnesota Resources. Sept. 2014, 48 pp.

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Runkel, Anthony C.; Steenberg, Julia R.; Tipping, Robert G.; Retzler, Andrew J.. (2014). OFR14-02, Geologic controls on groundwater and surface water flow in southeastern Minnesota and its impact on nitrate concentrations in streams. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/162612.

Tipping, Robert C., Rantala, Mathew, Alexander, E. Calvin, Jr., Gao, Yongli and Green, Jeffrey A. (2015) History and Future of the Minnesota Karst Feature Database. In: Daniel H. Doctor, Lewis Land and J. Brad Stephenson (editors), National Cave & Karst Research Institute Symposium 5, Sinkholes and the Engineering and Environmental Impacts of Karst, Proceedings of the 14th Multidisciplinary Conference, Oct 5-9, 2015, Rochester, MN, NCKRI, Carlsbad, NM MN, p. 263-270.

Lewiston Interchange 2008 Traces -- 22 July 2008 (2 Traces)

Trace Input Location 1: Thompson West Sinkhole (MN85:D00449, 590,556 E / 4,865,291 N, NAD 83, Zone 15):

Poured 1,584.08 grams **Rhodamine WT** (17.7 weight %) into the west Cliff Thompson, Jr. sinkhole on 22 Jul 2008 at 15:36. The Lewiston Fire Department supplied approximately 1,000 gallons of water to flush the dye into the sinkhole.

Trace Input Location 2: Olson Stream Sink in a drainageway (MN85:B00009, 588,178 E / 4,865,403 N, NAD 83, Zone 15):

Poured 1,083.26 grams **Uranine C** (35 weight %) into a drainageway with a swallet hole on 22 Jul 2008 at 16:04. The Lewiston Fire Department supplied approximately 1,200 gallons of water to flush the dye into the sinkhole.

Field Personnel at Inputs and/or Sampling: Jeff Green, Andrew Peters

Lab Personnel: Andrew J. Luhmann, Betty J. Wheeler, Dr. E. Calvin Alexander, Jr.

Carbon (Bug) Analysis Results

Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		19 Jun to 22 Jul 2008	Dye Input 22 Jul 2008	22 Jul to 29 Jul 2008	29 Jul to 8 Aug 2008	8 Aug to 27 Aug 2008	27 Aug to 16 Sep 2008	16 Sep to 3 Oct 2008	3 Oct to 17 Oct 2008	17 Oct to 30 Oct 2008	30 Oct to 20 Nov 2008	20 Nov to 4 Dec 2008	4 Dec 2008 to 22 Jan 2009	22 Jan to 25 Feb 2009	25 Feb to 16 Mar 2009	16 Mar to 2 Apr 2009	2 Apr to 28 Apr 2009	28 Apr to 28 May 2009	28 May to 24 Jun 2009
			Easting	Northing																		
85:X8 Bug set under Bridge on Thompson Rd. over Unnamed Creek, in Sec. 34 in Utica Twp	**MN85:X00008**	creek	588859	4866142	nd		nd	nd	nd	nd	nd	nd	nd	nd		Uran (7.5 σ)	nd	nd	nd	nd	Eos * (6 σ)	nd
85:X9 Bug set under Bridge on County 29 over Unnamed Creek, in Sec. 35 in Utica Twp.	**MN85:X00009**	creek	590369	4866025	nd		nd	nd	nd	nd	nd	nd	nd	nd		Uran (23 σ)	nd	Uran (3.1 σ)	Uran (18 σ)	Uran (7.0 σ)	Uran (33 σ) Eos * (17 σ)	Uran (23 σ) Eos * (6 σ)

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Carbon (Bug) Analysis Results

Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		19 Jun to 22 Jul 2008	Dye Input 22 Jul 2008	22 Jul to 29 Jul 2008	29 Jul to 8 Aug 2008	8 Aug to 27 Aug 2008	27 Aug to 16 Sep 2008	16 Sep to 3 Oct 2008	3 Oct to 17 Oct 2008	17 Oct to 30 Oct 2008	30 Oct to 20 Nov 2008	20 Nov to 4 Dec 2008	4 Dec 2008 to 22 Jan 2009	22 Jan to 25 Feb 2009	25 Feb to 16 Mar 2009	16 Mar to 2 Apr 2009	2 Apr to 28 Apr 2009	28 Apr to 28 May 2009	28 May to 24 Jun 2009
			Easting	Northing																		
85:X10 Bug set under Bridge on County 29 over Rush Creek, in Sec. 35 in Utica Twp.	**MN85:X00010**	creek	590419	4866129			nd	nd	nd	nd	lost	nd	nd	nd						nd	nd	SrB * (3 σ)
Thompson Spring (aka, Cliff Jr. Spring)	**MN85:A00314**	spring	590625	4865897	nd (9 Jul - 22 Jul)		RhWT (448 σ)	RhWT (297 σ)	RhWT (546 σ) (diluted 10x)	RhWT (295 σ)	RhWT (2170 σ)	RhWT	RhWT	RhWT (540 σ)		RhWT (426 σ)	RhWT	RhWT (9.5 σ)	RhWT (112 σ)	RhWT (283 σ)	RhWT (545 σ)	RhWT (154 σ)
Spring Upstream of 85X11 (aka, 85:X11 Upstream Spring)	**MN85:A00315**	spring	591204	4865662			nd	nd	nd	lost	lost											
85:X11 Bug set under upstream Bridge on Enterprise Valley Drive over Rush Creek, in Sec. 35 in Utica Twp.	**MN85:X00011**	creek	591375	4865548	nd		RhWT (62 σ)	RhWT (34 σ)	nd	nd	nd	nd	nd	nd		nd			nd	nd	Eos * (8 σ)	
85:X12 Bug set east of X11 in Unnamed Tributary to Rush Creek, in Sec. 35 in Utica Twp.	**MN85:X00012**	creek	591528	4865600	nd		nd	nd	nd	nd	Eos * (18 σ)	Eos * (17 σ)	nd									

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Carbon (Bug) Analysis Results

Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		19 Jun to 22 Jul 2008	Dye Input 22 Jul 2008	22 Jul to 29 Jul 2008	29 Jul to 8 Aug 2008	8 Aug to 27 Aug 2008	27 Aug to 16 Sep 2008	16 Sep to 3 Oct 2008	3 Oct to 17 Oct 2008	17 Oct to 30 Oct 2008	30 Oct to 20 Nov 2008	20 Nov to 4 Dec 2008	4 Dec 2008 to 22 Jan 2009	22 Jan to 25 Feb 2009	25 Feb to 16 Mar 2009	16 Mar to 2 Apr 2009	2 Apr to 28 Apr 2009	28 Apr to 28 May 2009	28 May to 24 Jun 2009
			Easting	Northing																		
85:X12 Bug set east of X11 in Unnamed Tributary to Rush Creek, in Sec. 35 in Utica Twp.	**MN85:X00012**	creek	591528	4865600	**nd**		**nd**	**nd**	**nd**	**nd**	Eos * (18 σ)	Eos * (17 σ)	**nd**									
85:X13 Bug set under downstream Bridge on Enterprise Valley Drive over Rush Creek, in Sec. 35 in Utica Twp.	**MN85:X00013**	creek	591448	4865280	Uran * (7 σ)		**RhWT (45 σ)**	**RhWT (74 σ)**	**RhWT (5.0 σ)**	**nd**	**nd**	**nd**	**nd**	**nd**				**nd**	**nd**	**nd**	**nd**	
I-90 Crossing Bug set on Rush Creek south of I-90 bridge, Sec. 2 of Fremont Twp.	**MN85:X00016**	creek	591469	4864950			**RhWT (14 σ)**	**RhWT (29 σ)**	**RhWT (7.0 σ)**	**nd**	**nd**	**nd**	**nd**	**nd**		**nd**				**nd**		
Rush Creek Confluence Bug set on Rush Creek just upstream of confluence with Ferguson Creek, Sec. 18 in Hart Twp.	**MN85:X00015**	creek	593709	4861163			**RhWT (41 σ)** (18 Jul - 31 Jul)	**RhWT (156 σ)** (31 Jul - 8 Aug)	**RhWT (41 σ)**	**nd**	**nd**	**nd**	**nd**	**nd**	**nd**			**nd**	**nd**	**nd**	Eos * (20 σ)	

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Carbon (Bug) Analysis Results

Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		19 Jun to 22 Jul 2008	Dye Input 22 Jul 2008	22 Jul to 29 Jul 2008	29 Jul to 8 Aug 2008	8 Aug to 27 Aug 2008	27 Aug to 16 Sep 2008	16 Sep to 3 Oct 2008	3 Oct to 17 Oct 2008	17 Oct to 30 Oct 2008	30 Oct to 20 Nov 2008	20 Nov to 4 Dec 2008	4 Dec 2008 to 22 Jan 2009	22 Jan to 25 Feb 2009	25 Feb to 16 Mar 2009	16 Mar to 2 Apr 2009	2 Apr to 28 Apr 2009	28 Apr to 28 May 2009	28 May to 24 Jun 2009
			Easting	Northing																		
Ferguson Confluence Bug set on Ferguson Creek just upstream of confluence with Rush Creek, Sec. 18 in Hart Twp.	**MN85:X00014**	creek	593640	4861171				**nd** (31 Jul - 8 Aug)	**nd**	**lost**	**nd**	**nd**	**nd**	**nd**	**nd**	**Uran**	**nd**	**nd**	**nd**	**nd**	Eos * (25 σ)	

RhWT indicates Rhodamine WT dye detected

Uran indicates Uranine (fluorescein) dye detected

Eos * indicates Eosine from some other unknown source

SrB * indicates Sulforhodamine B from some other unknown source

Uran * indicates Uranine (fluorescein) from some other unknown source

nd indicates no dye detected

lost indicates bug was lost in the field

(yellow cell) indicates no bug was received by the lab

Lewiston Interchange 2008 Traces -- 22 July 2008 (p. 5)

Water Analysis Results

Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		18 Jul 2008	22 Jul 2008	Dye Input 22 Jul 2008	23 Jul 2008	24 Jul 2008	25 Jul 2008	29 Jul 2008	31 Jul 2008	8 Aug 2008	16 Sep 2008	3 Oct 2008	25 Feb 2009
			Easting	Northing												
85:X10 Sample from Rush Creek under Bridge on County 29, in Sec. 35 in Utica Twp.	**MN85:X00010**	creek	590419	4866129												SrB * (9 σ)
Thompson Spring (aka, Cliff Jr. Spring)	**MN85:A00314**	spring	590625	4865897				**nd**	**nd**	**nd**	**RhWT (4370 σ)**		**RhWT (383 σ)**			
Spring Upstream of 85X11 (aka, 85:X11 Upstream Spring)	**MN85:A00315**	spring	591204	4865662										**nd**	**nd**	
85:X11 Sample from Rush Creek, under upstream Bridge on Enterprise Valley Drive, in Sec. 35 in Utica Twp.	**MN85:X00011**	creek	591375	4865548							**RhWT (189 σ)**		**RhWT (12 σ)**			
85:X13 Sample from Rush Creek, under downstream Bridge on Enterprise Valley Drive, in Sec. 35 in Utica Twp.	**MN85:X00013**	creek	591448	4865280							**RhWT (232 σ)**		**RhWT (10 σ)**			

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Water Analysis Results

Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		18 Jul 2008	22 Jul 2008	Dye Input 22 Jul 2008	23 Jul 2008	24 Jul 2008	25 Jul 2008	29 Jul 2008	31 Jul 2008	8 Aug 2008	16 Sep 2008	3 Oct 2008	25 Feb 2009
			Easting	Northing												
I-90 Crossing Sample from Rush Creek south of I-90 bridge, Sec. 2 of Fremont Twp.	**MN85:X00016**	creek	591469	4864950		Uran * (16 σ)					RhWT (192 σ)		RhWT (6.1 σ)			
Rush Creek Confluence Sample from Rush Creek just upstream of confluence with Ferguson Creek, Sec. 18 in Hart Twp.	**MN85:X00015**	creek	593709	4861163	**nd**							RhWT (58 σ)	RhWT (8.5 σ)			
Ferguson Confluence Sample from Ferguson Creek just upstream of confluence with Rush Creek, Sec. 18 in Hart Twp.	**MN85:X00014**	creek	593640	4861171	**nd**											

RhWT indicates Rhodamine WT dye detected

Uran indicates Uranine (fluorescein) dye detected

SrB * indicates Sulforhodamine B from some other unknown source

Uran * indicates Uranine (fluorescein) from some other unknown source

nd indicates no dye detected

(yellow cell) indicates no water sample was received by the lab